Wee Bee

ENGINEERING DATA

PREPARED BY:

KEN S. COWARD

1946 - 1949

COPY NO. 2

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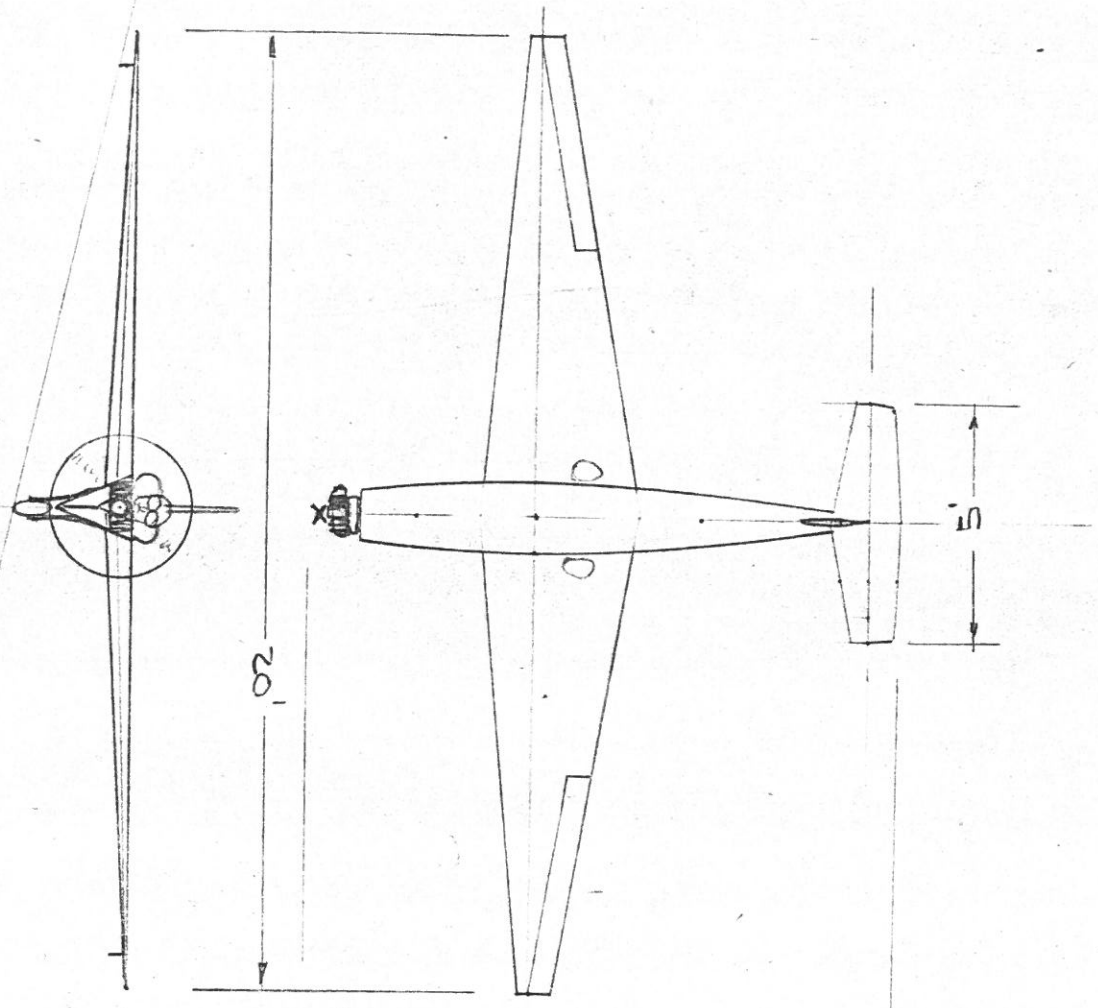
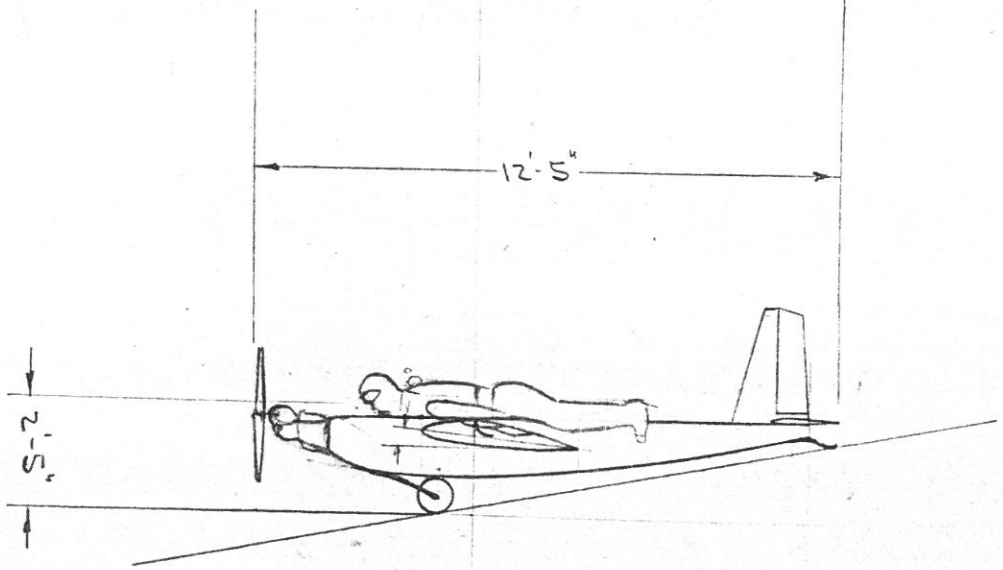
NOTE:
THIS IS ONLY ABOUT 5% OF ENGINEERING DATA ON THE ORIGINAL WEE BEE. 95% REMAINS WITH KEN COWARD.

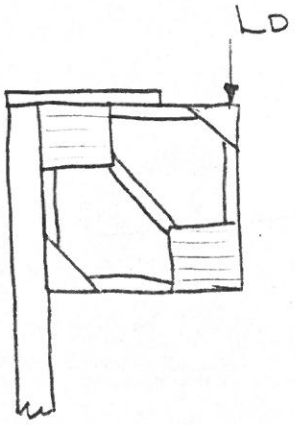
W. F. CHANA
6/5/95

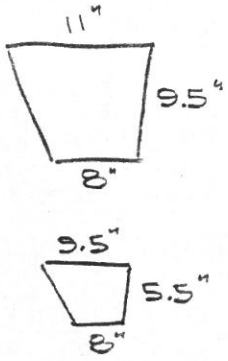




SCALE: 1" = 4'

RIB SPECIMEN TEST





BUCKETS WEIGH APPROX. 5#

$$LD = (9.5)\pi\frac{\overline{9.5}^2}{4}\frac{(62.5)}{(144)(12)} + (5.5)\pi\frac{\overline{8.75}^2}{4}\frac{(62.5)}{(144)(12)} + 5$$

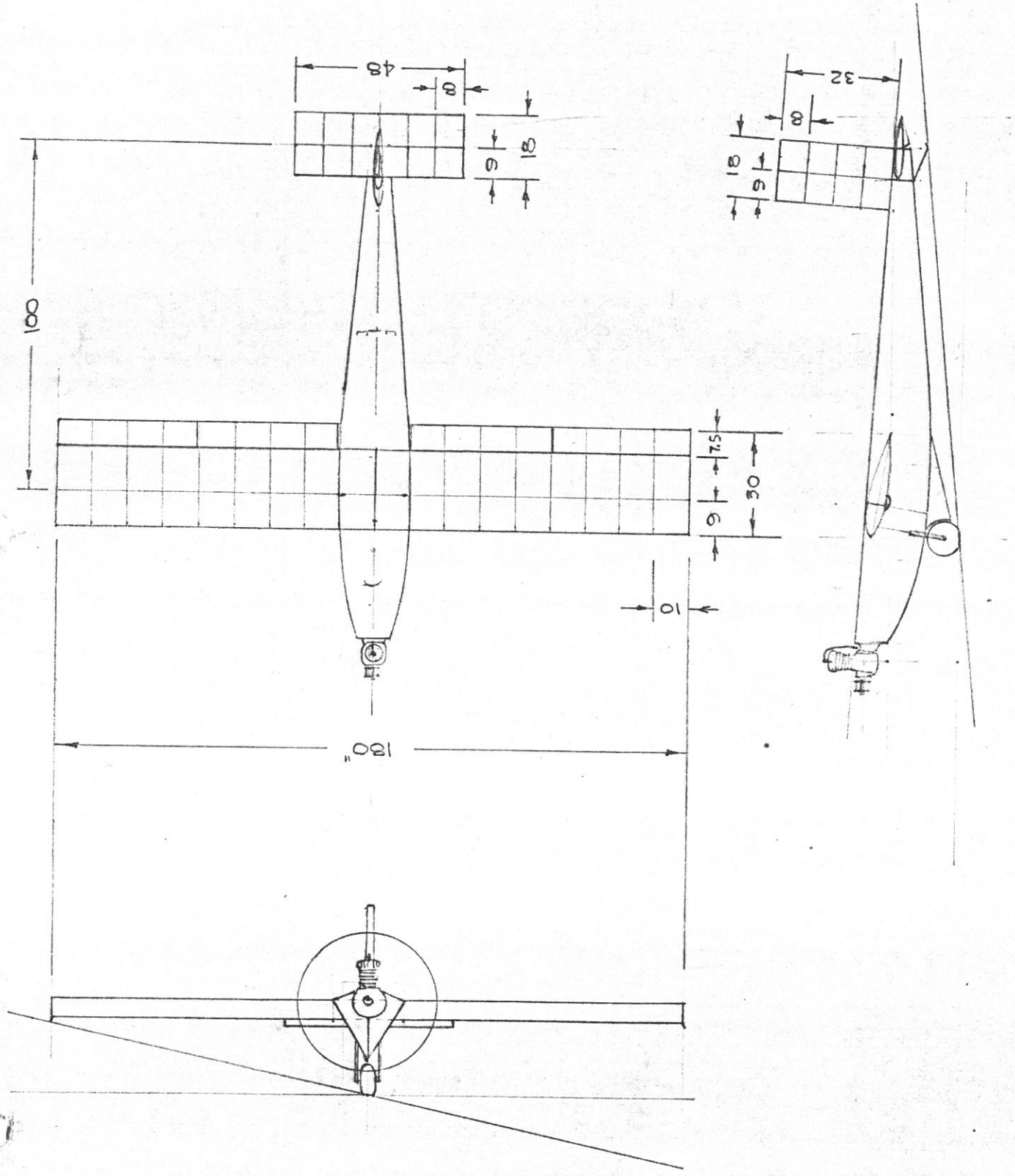
$$= 24.4 + 12 + 5$$

$$= 41.^{\#}$$

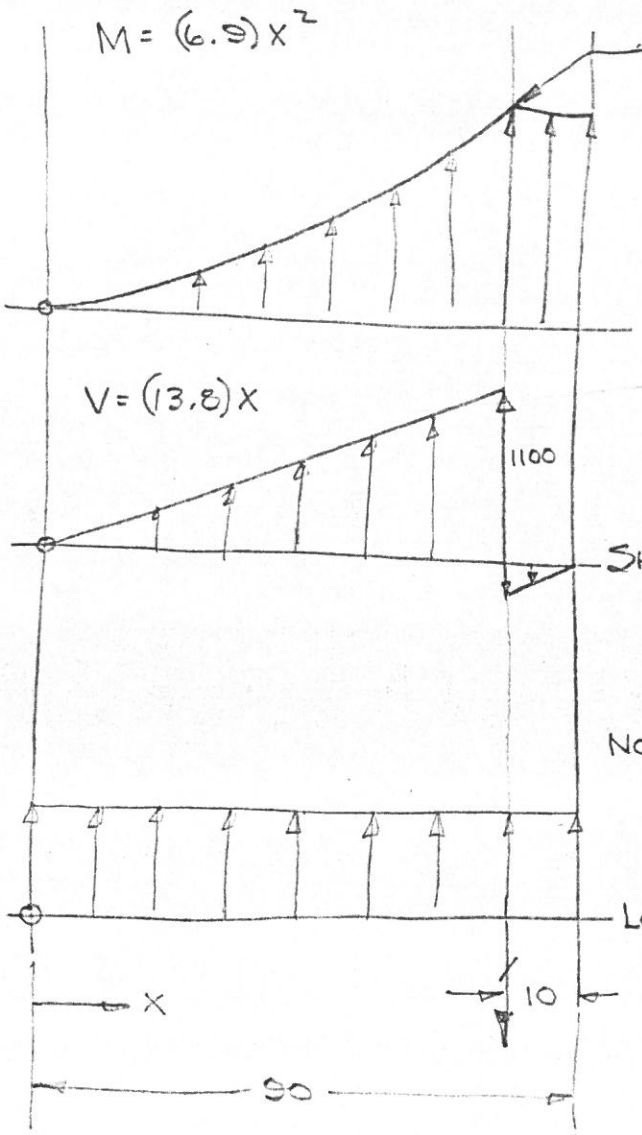
% OF 6g LOAD $= \left(\frac{41}{23(1.25)}\right) = 1.43$ DES. ULT.

N LOAD $= 6\left(\frac{41}{23(1.25)}\right) = 8.55$ ULT. TEST LOAD

* REQ. BY CAA


48
8
18
6
100
32
8
18
6
7.5
30
6
10
180"

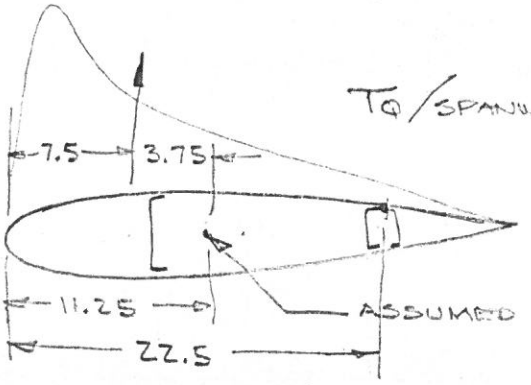
ULT. RUNNING LOAD, SHEAR, & MOMENT - WING



NORMAL LOAD / WING = $\frac{1}{2}(300 - 25^{*})\ 9^{\dagger}$
= 1240 #

LOADING / SPANWISE INCH = $\frac{1240}{90}$ = 13.8 #/″

TORSION



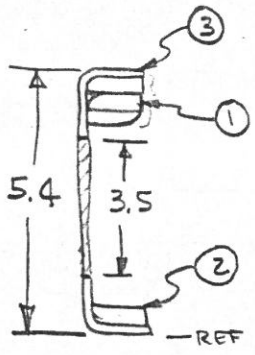
TQ / SPANWISE INCH = (13.8)(3.75) = 51.7 ″#

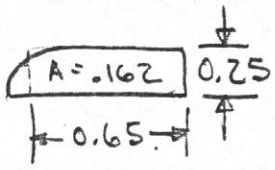
TORSION AT STA 0 = (51.7)(90) = 4660 ″#

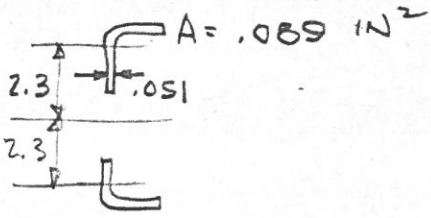
† ULTIMATE LOAD FACTOR

* WING WEIGHT

SPAR DESIGN – STR. CHECK







SEG	A	d	Ad	Ad²	$I_{c.g.}$
1	0.486	4.974	2.42	12.05	—
2	0.251	0.176	0.04	.01	—
3	0.089	5.000	0.45	2.25	—
Σ	0.826	$\bar{d}$ = 3.52	2.91	14.31	

$y_c = 1.88$

$I = 14.31 - 10.25 = 4.06 \text{ IN.}^4$

$f_b = \frac{Mc}{I} = \frac{(44{,}200)(1.88)}{4.06} = 20{,}500 \text{ \#/IN}^2$

SEG	A	d	Ad	Ad²	$I_{c.g.}$
1	0.324	5.100	1.65	8.42	—
2	.251	.176	.04	.01	—
3	.089	5.000	0.45	2.25	—
Σ	0.664	$\bar{d}$ = 3.22	2.14	10.68	

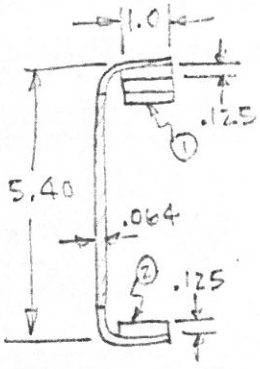
$y_c = 2.18$

$I = 10.68 - 6.90 = 3.78 \text{ IN}^4$

$M = \frac{f_b I}{c} = \frac{(20{,}000)(3.78)}{2.18} = 34{,}700 \text{ "\#}$

$x = \sqrt{\frac{M}{6.9}} = \sqrt{\frac{34{,}700}{6.9}} = \sqrt{5030} = \underline{71.0}$ "

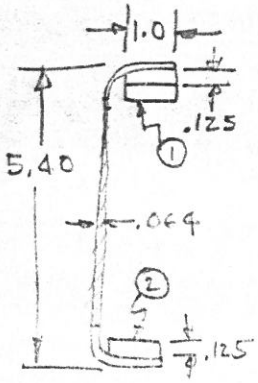
SPAR DESIGN



Sec.	A	d	Ad	Ad^2	$I_{c.g.}$
1	.475	5.18	2.46	12.75	—
2	.225	.09	.02	—	—
Σ	.700	$\bar{d}$ = 3.54	2.48	12.75	—

$I = 12.75 - 8.78 = 3.97 \text{ IN.}^4$

$$f_b = \frac{Mc}{I} = \frac{(4.4200)(1.86)}{3.97} = 20{,}700\ \#/\text{IN}^2$$

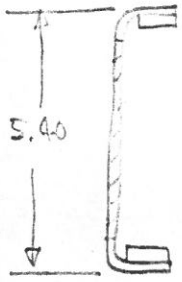


Sec.	A	d	Ad	Ad^2	$I_{c.g.}$
1	.350	5.24	1.835	9.60	—
2	.225	.09	.020	—	—
Σ	.575	$\bar{d}$ = 3.22	1.855	9.60	—

$I = 9.60 - 5.97 = 3.63 \text{ IN.}^4$

$$M = \frac{f_b I}{c} = \frac{(20{,}000)(3.63)}{2.18} = 33{,}300\ \text{IN\#}$$

$$M = (6.9)x^2; \quad x = \sqrt{\frac{M}{6.9}} = \sqrt{\frac{33{,}300}{6.9}} = \sqrt{4830} = \underline{69.5''}$$

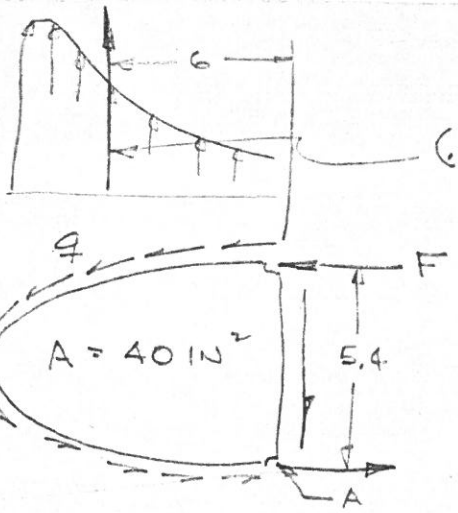


$$I = 2Ad^2 = (2)(.225)(2.61)^2 = 3.07 \text{ IN}^4$$

$$M = \frac{(20{,}000)(3.07)}{2.70} = 22{,}800\ \text{IN\#}$$

$$x = \sqrt{\frac{22{,}800}{6.9}} = \sqrt{3300} = \underline{57.4''}$$

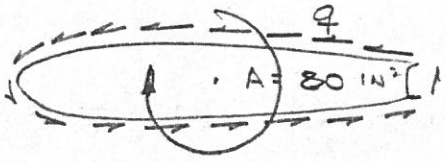
RIBS



$(.68)^{\#}(138) = 94^{\#}$

TO DETERMINE q:

$$T = (51.7)(10)^{*} = 517^{\#}$$



$$q = \frac{T}{2A} = \frac{517}{(2)(80)} = 3.23\ \#/''$$

AXIAL FORCE IN SKIN CONNECTING FWD. RIB WITH CENTER RIB:

$$F = \frac{1}{5.4}\left[(94)(6) - (2)(3.23)(40)\right] = \frac{(564 - 258)}{5.4} = \frac{306}{5.4}$$

$$= 56.7^{\#}$$

IF AN .032 STRIP IS USED TO REINFORCE THE SKIN,

$$f_c = \frac{56.7}{(0.5)(.032 + .010)} = 2700\ \#/IN^2$$

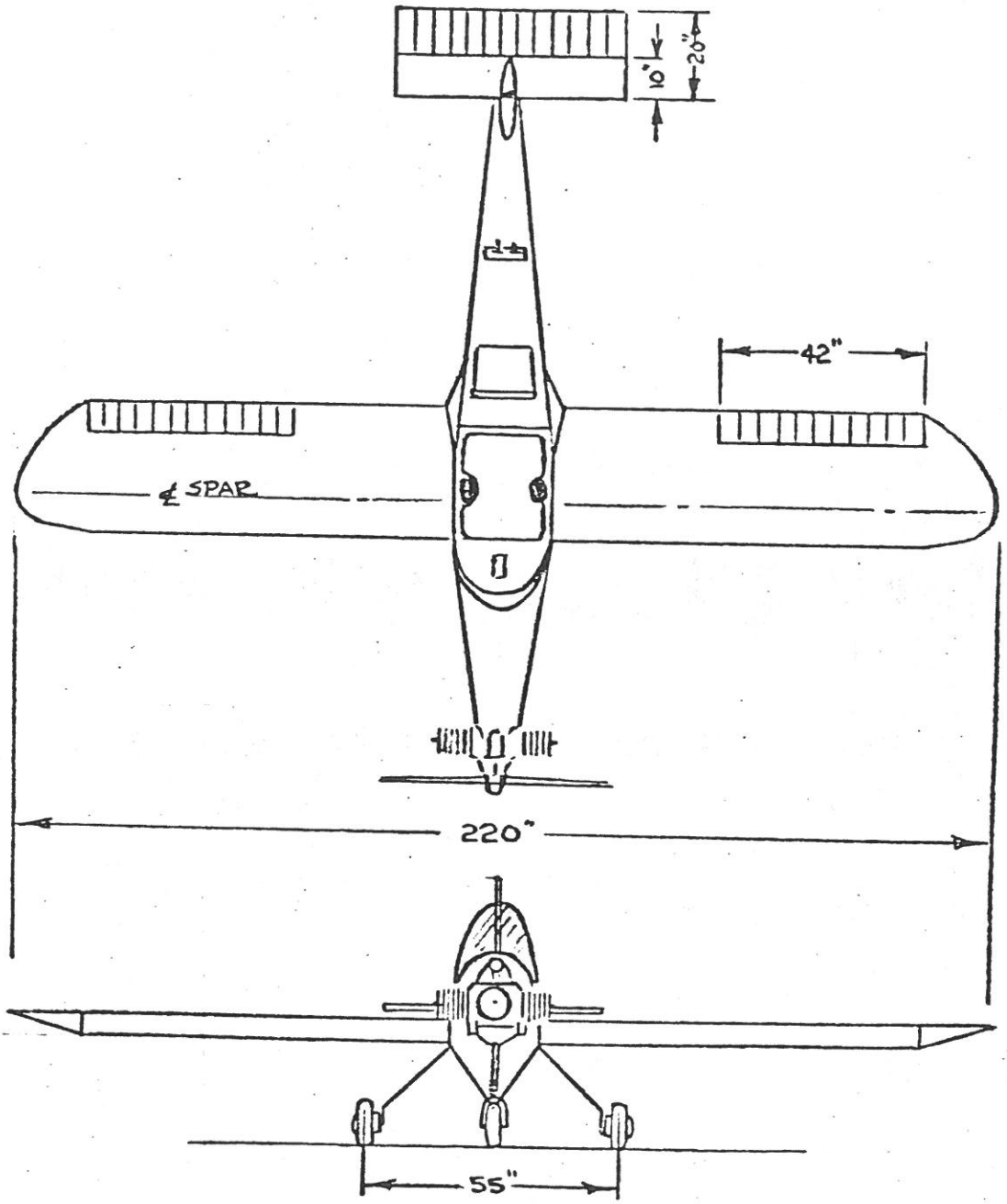
$$L/\rho = \frac{1.0}{(.29)(.042)} = 82$$

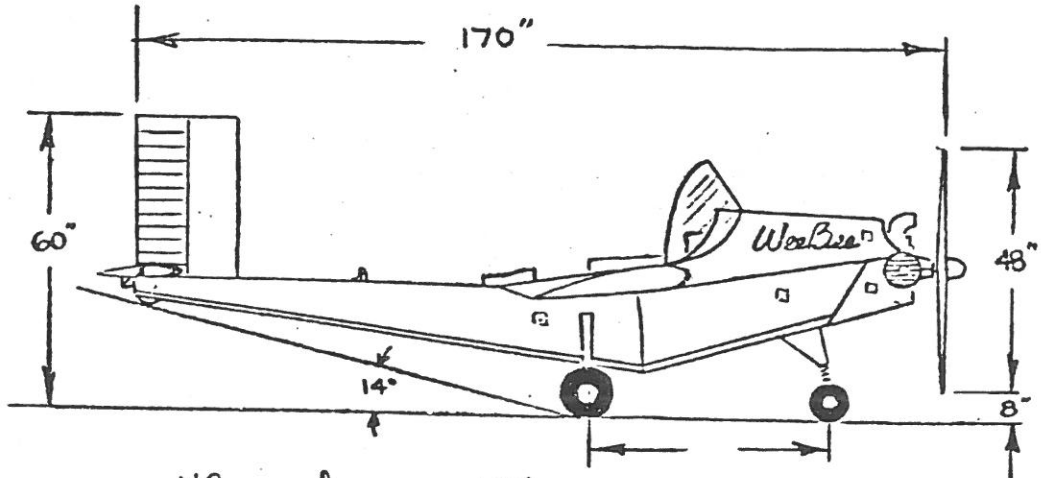
$$F_c = 15{,}000\ \#/IN^2 \text{ — OK}$$

AN .016 STRIP CAN BE USED ON THE LOWER SIDE

F. % OF TOTAL LOAD FWD OF SPAR

* RIB SPACING





the

WEE BEE

Power..... 28 BHP
Gross Wht..410 Lbs.
Design Criteria:
CAR 03 Nor.Category
Aero Parameters:
Wing Loading.-9.3 #/ft.
Power Loading-13.7 #/BHP
Aspect Ratio -7.6
Airfoils:
Wing & Tail
0018 0012-64

DESIGN K Cornwall DRAWN W Chase DATE 6-1-48

PERFORMANCE

$$THP = BHP\eta = \frac{DV_T}{375} = \frac{C_D V_c^2 S V_c \sqrt{1/6}}{(391)(375)} = \frac{C_D V_c^3 S \sqrt{1/6}}{146{,}600}$$

$$C_D = C_{D_o} + \frac{C_L^2}{\pi Re} = \frac{f}{S} + \frac{C_L^2}{\pi Re}$$

$$C_L = \frac{W(391)}{V_c^2 S} \quad ; \quad C_L^2 = \frac{W^2(153{,}000)}{V_c^4 S^2}$$

PARASITE THP:

$$THP_p = \frac{V_c^3 S \sqrt{1/6} f}{(146{,}600)S} = \frac{V_c^3 \sqrt{1/6} f}{146{,}600} \longleftarrow$$

INDUCED THP:

$$THP_i = \frac{V_c^3 S \sqrt{1/6}\, W^2(153{,}000)}{146{,}600 \;\; \pi Re \; V_c^4 S^2} = \frac{\sqrt{1/6}\, W^2}{(3.01) Re \, V_c S} \longleftarrow$$

FOR MODEL 1:

1. $f = 1.5$
2. $e = 0.6$
3. $W = 300$ & 350
4. $R = 6$

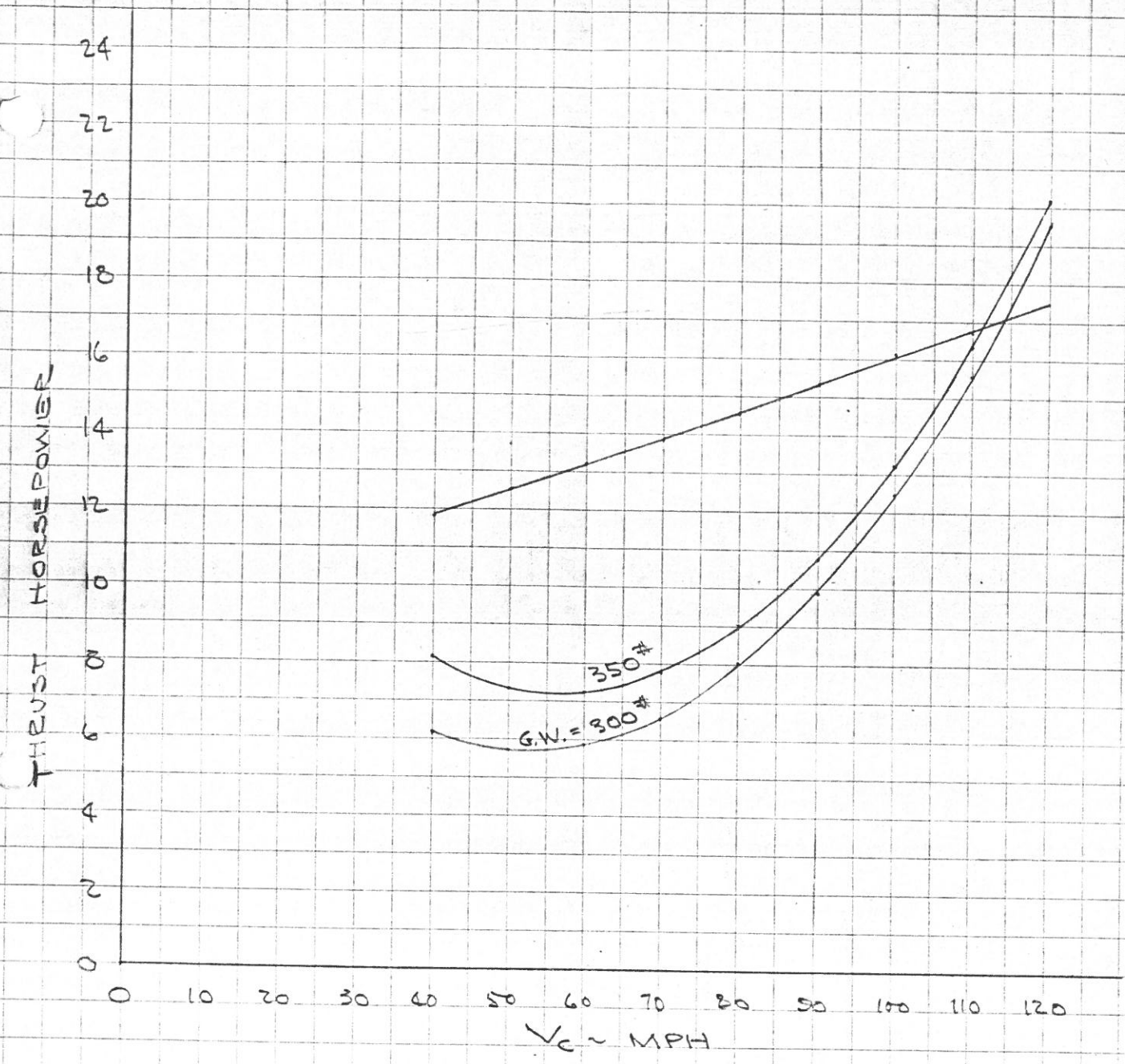
$S = 37.5$

$$THP_p = \frac{V_c^3 (1.5)}{146{,}600} = \frac{V_c^3}{97{,}600}$$

$$THP_i = \frac{300^2}{(3.01)(6)(0.6)(37.5)V_c} = \frac{222}{V_c}(300) \qquad \frac{302}{V_c}(350)$$

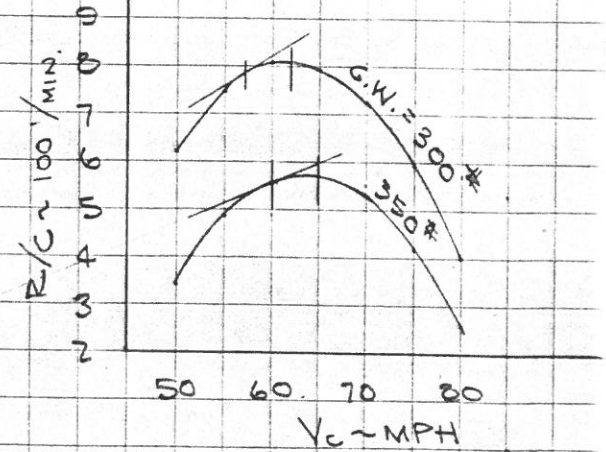
V_c	V_c^3	THP_p	THP_i 300#	THP_i 350#	THP 300#	THP 350#	RPM	η	THP_A *
40	64 000	0.65	5.55	7.55	6.20	8.20	3700	0.50	11.85
50	125 000	1.28	4.44	6.04	5.72	7.32	3725	.525	12.55
60	216 000	2.21	3.70	5.04	5.91	7.25	3750	.55	13.22
70	342000	3.50	3.17	4.31	6.67	7.81	3775	.575	13.90
80	512000	5.24	2.78	3.77	8.02	9.01	3800	0.60	14.62
90	730000	7.46	2.47	3.36	9.93	10.82	3825	.625	15.34
100	1000 000	10.22	2.22	3.02	12.44	13.24	3850	.65	16.07
110	1330 000	13.60	2.02	2.75	15.62	16.35	3875	.675	16.72
120	1730000	17.70	1.85	2.52	19.55	20.22	3900	0.70	17.50

$$THP_A = 25\left(\frac{RPM}{3900}\right)\eta = (.00641)(RPM)\eta$$

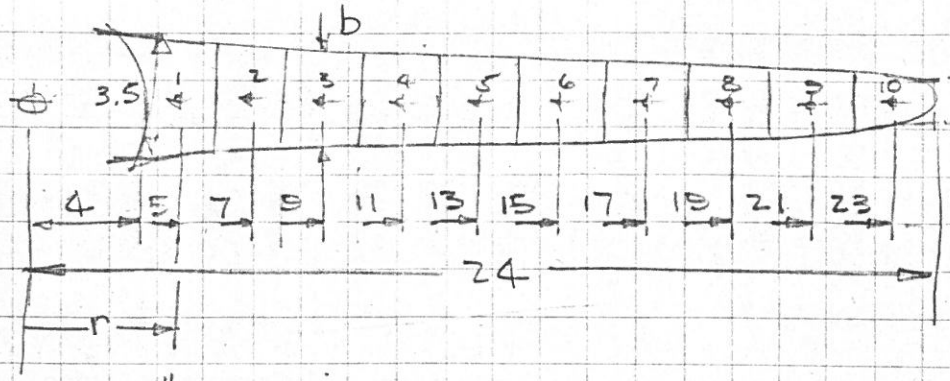


$$R/C = \frac{\Delta THP\ (33000)}{W}$$

V_c	ΔTHP_{300}	ΔTHP_{350}	R/C_{300}	R/C_{350}
50	5.65	3.65	621	344
55	6.83	5.23	752	493
60	7.31	5.97	805	563
65	7.23	6.09	795	574
70	6.60	5.61	726	530
75	5.41	4.52	595	425
80	3.63	2.83	400	267



BLADE-ELEMENT ANALYSIS OF 48CJ33



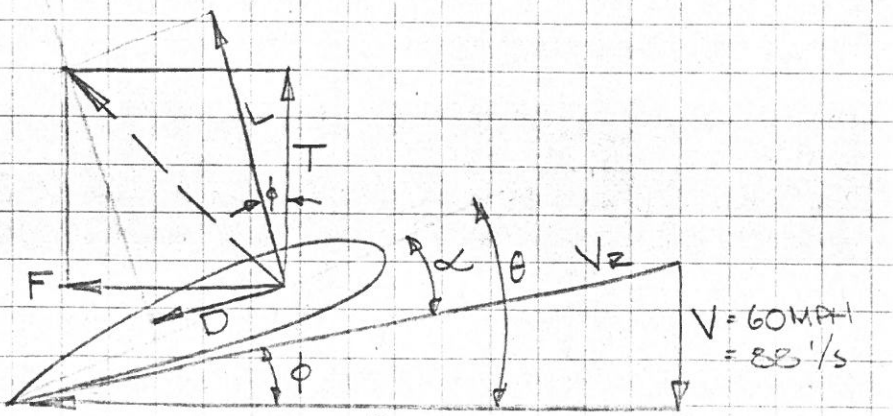
PITCH = 33"

RPM = 3000

V_c = 60 MPH = V_T

RAF 6 SEC.

$q = \frac{60^2}{391} = 9.21$



$\frac{2\pi r n}{(60)(12)}$ FOR r IN INCHES

$= \frac{2\pi r\, 3000}{720} = 26.2\, r$

$dA = 2b$

$\tan\phi = 88/(26.2)r$

$\tan\theta = 33/2\pi r$

$L = C_L q S = C_L q \frac{S}{144}$; $\alpha = \theta - \phi$

RESULTS:

$$TP = \frac{TV}{375} = \frac{(96.5)(60)}{375} = 15.44 \text{ THP}$$

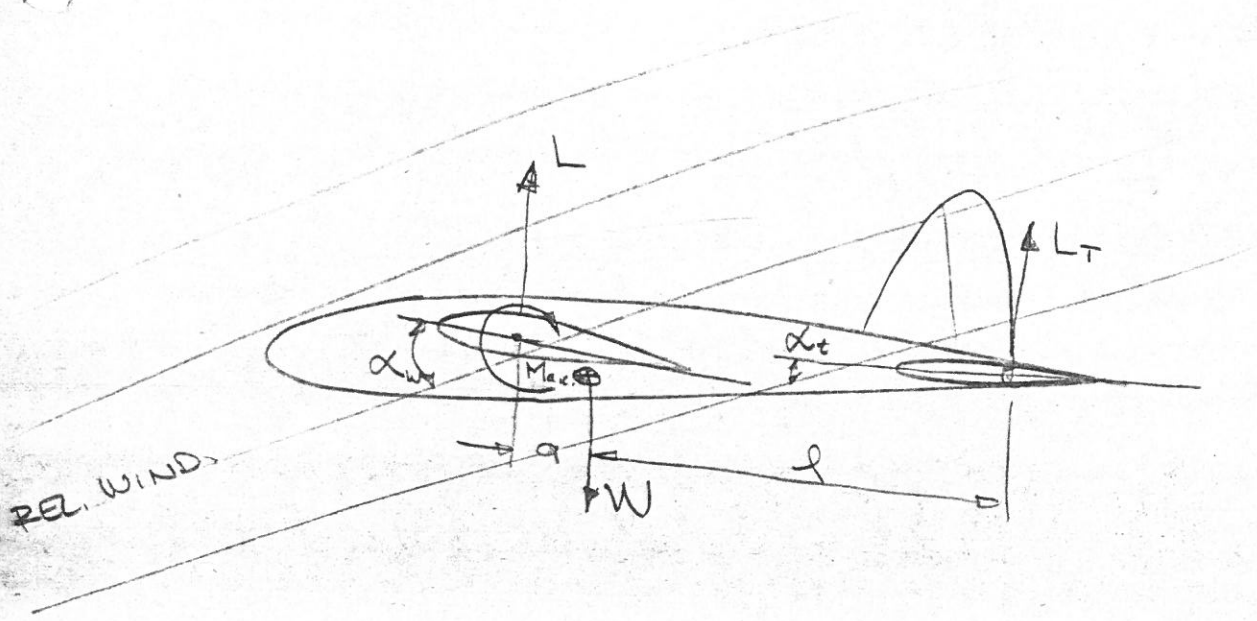
$$BHP = \frac{T_Q N}{5252} = \frac{(39.24)(3000)}{5252} = 22.4$$

$$\eta = \frac{THP}{BHP} = \frac{15.44}{22.4} = 0.69$$

-35 ENGINE:

$BHP = K\,RPM$; $K = \frac{22.4}{3000} = .747$; **BHP = .747 RPM** (-35 ENG.)

COMPUTED LONG. STABILITY



SIMPLIFYING ASSUMPTION:

DRAG ACTS THRU C.G.

$$M_{c.g.} = La + M_{a.c.} - L_T l$$

$$C_{M_{c.g.}} q S_w c = C_L q S_w a + C_{M_{a.c.}} q S_w c - C_{L_T} q_t S_t l$$

$$C_{M_{c.g.}} = C_L \frac{a}{c} + C_{M_{a.c.}} - C_{L_T} \frac{q_t}{q} \frac{S_t}{S_w} \frac{l}{c}$$

$$C_{L_T} = \frac{dC_{L_T}}{d\alpha_t} \alpha_t$$

$$\alpha_t = \alpha_w - \epsilon + i \; ; \; C_{L_T} = \frac{dC_{L_T}}{d\alpha_t} (\alpha_w + i - \epsilon)$$

$$C_{M_{c.g.}} = C_L \frac{a}{c} + C_{M_{a.c.}} - \frac{q_t}{q} \frac{S_t}{S_w} \frac{l}{c} \frac{dC_{L_T}}{d\alpha_t} (\alpha_w + i - \epsilon)$$

$$\frac{dC_{M_{c.g.}}}{dC_L} = \frac{a}{c} + \frac{dC_{M_{a.c.}}}{dC_L} - \left(\frac{q_t}{q} \frac{S_t}{S_w} \frac{l}{c} \frac{dC_{L_T}}{d\alpha_t} \right) \left(\frac{d\alpha_w}{dC_L} - \frac{d\epsilon}{dC_L} \right)$$

4

INDEX OF STABILITY

$$= \frac{S_t}{S_w} \frac{l}{c} \qquad (.696)$$

COMPARISON

AIRPLANE	S_T	S_w	S_t/S_w	l	c	l/c	TAIL VOLUME COEF. $\frac{S_t}{S_w}\frac{l}{c}$
AERONCA KC	25.1	146.4	.172	13.1	4.1	3.2	.55
LUSCOMBE 90	21.8	140.0	.156	14.4	5.5	2.6	.41
CUB J-3	25.3	178.5	.142	14.0	5.4	2.6	.37

REF: "AVIATION" FEB '39

FROM THE ABOVE, IT APPEARS THAT A GOOD VALUE FOR S_t/S_w WOULD BE .16, OR $S_t = 6.4$

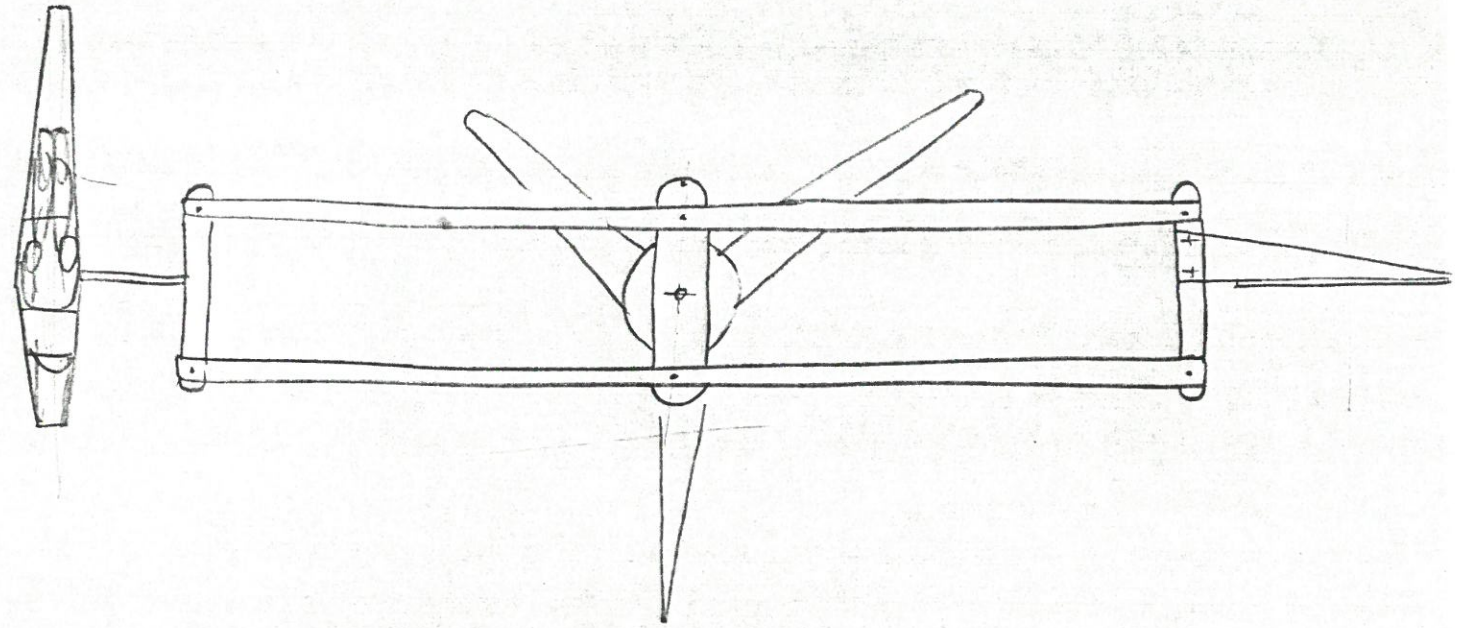
& $l/c = 2.8$, OR $l = 6.44'$

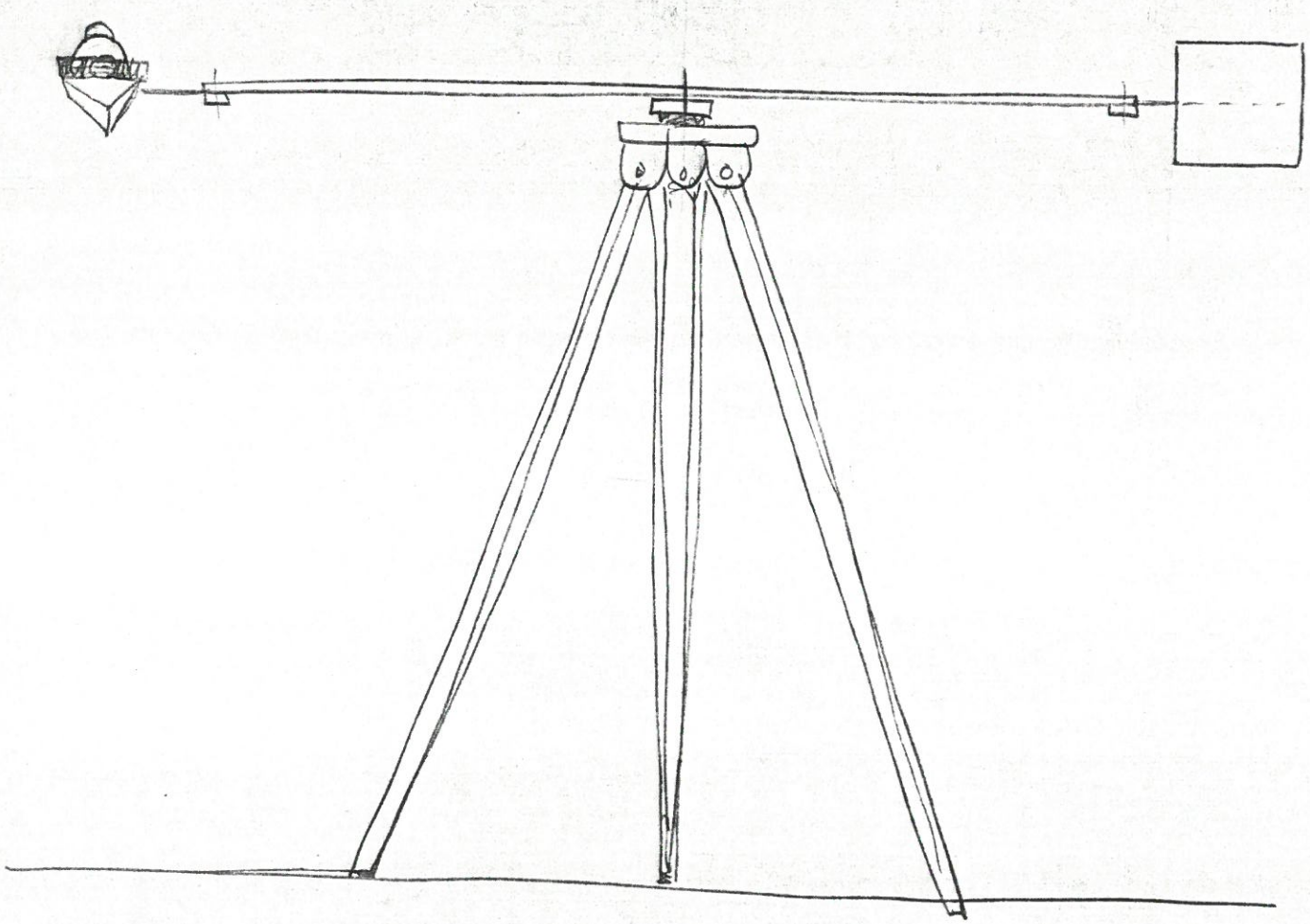
SAY $S_t = 6.0$ FT^2

$l = 7.0$ FT

$$\frac{S_t}{S_w} \cdot \frac{l}{c} = .456$$

which is better than the Luscombe and Cub, but not as good as Aeronca.





Wee Bee FUSELAGE
(MINIMUM DRAG TEST)

DRAG REF AREA

10
8
6
4
2
0

-30 -20 -10 0 +10

β

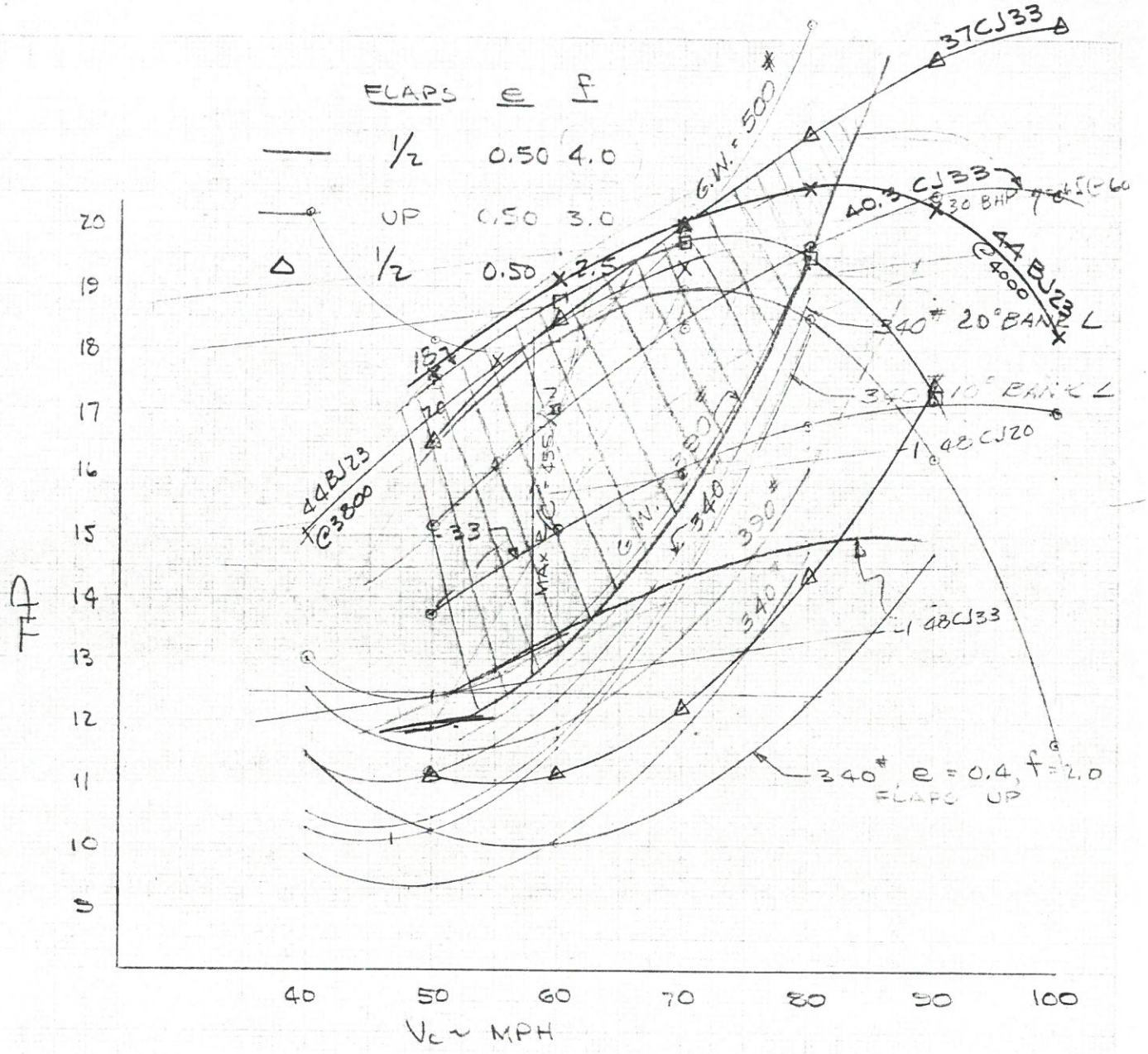
WITH OUT CANOPY +
WITH CANOPY ⊙

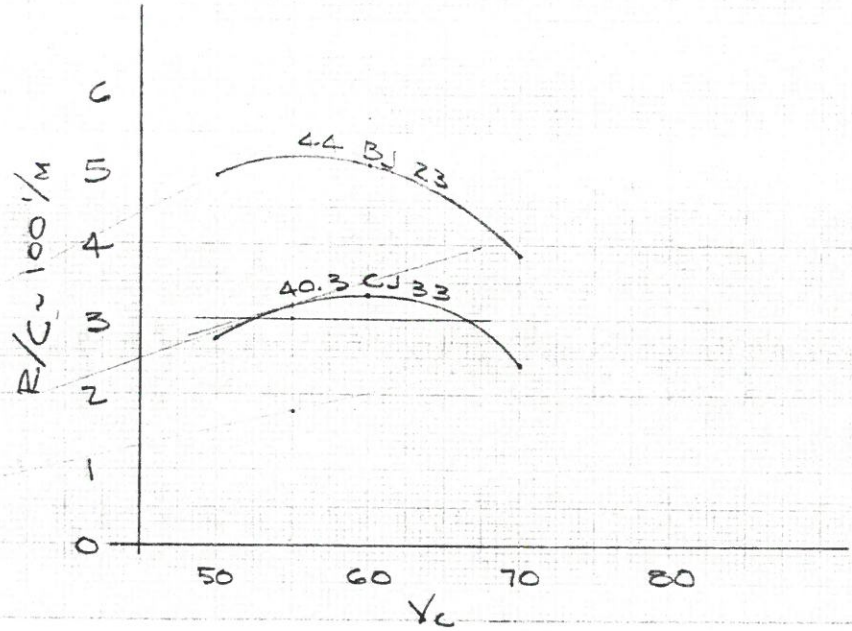
PRESENT β
@ 65 MPH

15°

DESIRED β

BY CHANA COWARD
3/15/99


FLAPS e f
1/2 0.50 4.0
UP 0.50 3.0
1/2 0.50 2.5
37CJ33
G.W. = 500#
40.3 CJ33
30 BHP
44 BJ23
@4000
340# 20° BANK L
340 10° BANK L
48 CJ20
44BJ23
@3800
G.W. = 380#
340
390#
340
48CJ33
340# e = 0.4, f = 2.0
FLAPS UP
TP
Vc ~ MPH


44 BJ 23
40.3 CJ 33
R/C ~ 100 '/M
Vc

DRAG REDUCTION USING STEEL GEAR:

DD GEAR EQUIV. FLAT PLATE = (0.2)(1.) = 0.2
, SAY 0.2 FT²

DRAG AT 55 $\left(\frac{q}{f} = 7.73\right)$

$= (0.2)(7.73) = 2.32^{\#}$

$THP @ 55 = (30)(.6) = 18 = \frac{D(55)}{375}$; $D = 123^{\#}$

$\Delta THP = 18 - \frac{(120.7)(55)}{375} = 18 - 17.7 \quad \underline{0.30}$

$\Delta R/C = \frac{(33,000)\Delta THP}{370} = \frac{(33,000)(0.3)}{370} = 27\ ^{1}/_{MIN}$

ΔR/C FROM WEIGHT INCREASE:

$R/C = \frac{33,000}{370}\left(15 - \frac{(6)(55)^3}{146,600} - \frac{370^2}{(3.01)(55)(18.33)^2(.5)}\right)$

$6.8 - 4.9$

$= \frac{(33,000)(3.3)}{370} = 294\ ^{1}/_{MIN}$

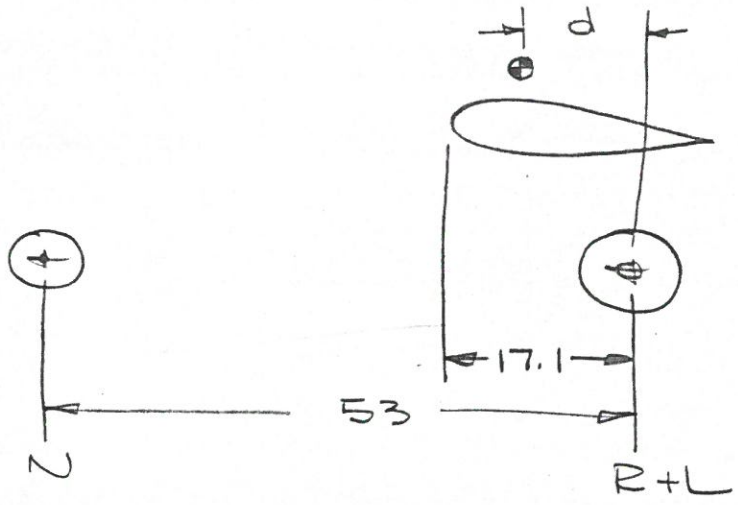
NOW, THE W INCREASE FROM 370 TO 380;
4.9 BECOMES 5.2

$R/C = \frac{(33,000)(3.0)}{380} = 261$

$\Delta R/C = 294 - 261 = 33\ ^{1}/_{MIN}$

CONCLUSION: THE DRAG REDUCTION IS SUFFICIENT TO REGAIN R/C OTHERWISE LOST DUE TO THE WEIGHT INCREASE (APPROX. 16#) OF THE SPRING GEAR.

WEIGHT & BALANCE



$$d = \frac{N \cdot 53}{N+R+L}$$

$$\%MAC = \frac{17.1-d}{30.4}(100$$

EMPTY:

N = 61
R = 61
L = 63
185
GAS 15
170 #

$$d = \frac{(61)(53)}{185} = 17.5$$

0.4" AHEAD OF L.E. MAC ← C.G.

← W.E

GROSS: INCL. KARL MONTIJO, PARACHUTE, & 15# FUEL

N = 53
R = 167
L = 161
381 #

← G.W.

$$d = \frac{(53)(53)}{381} = 7.37$$

$$\%MAC = \frac{17.1-7.37}{30.4}(100) = \underline{32\%\ MAC}$$ ←

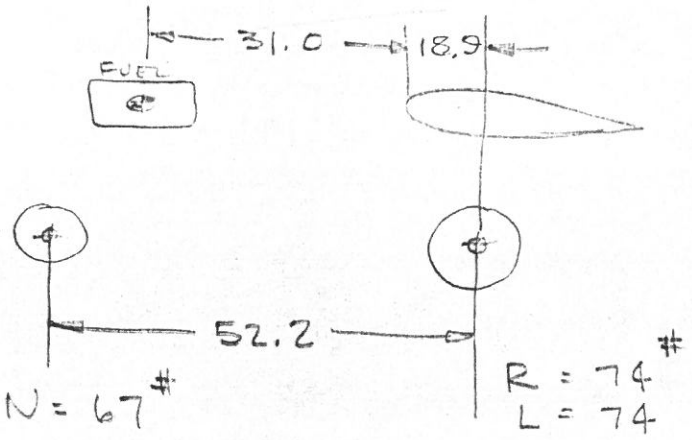
NOTE: THE ABOVE WEIGHINGS WERE HURRIEDLY CONDUCTED WITHOUT "ZERO-ING" SCALES. PARACHUTE WAS SIMULATED BY APPROX. EQUIVALENT WEIGHT.

WEIGHT & BALANCE

WEIGHING OF 12-30-49 @ GIBBS ON FOOD SCALES

CONFIG:

PROP. GABJ23
ENGINE - O-45-35
PNEU. NOSE WHEEL, SPRING GEAR, BRAKES.
NO FUEL



W.E. = 74+74+67 = 215# ← W.E.

WITH CHANA ABOARD:

N = 59 R = 160 L = 158

G.W. (MINUS FUEL) = 377# ← CHANA ALONE

PLUS 13# FUEL & 20# PARACHUTE:

G.W. = 410# ← G.W.

C.G. @ G.W. (CHANA ALONE)

$\Sigma M_{MAIN\ GEAR} : 0 = (59)(52.2) - (377)X \; ; \; X = 8.19"$

$18.9 - 8.19 = 10.71" \; ; \; \%MAC = \frac{10.71}{30} = 35.7$ ←

C.G. & G.W (CHANA + GAS + PARA.) ASSUME PARA @ MAIN GR.

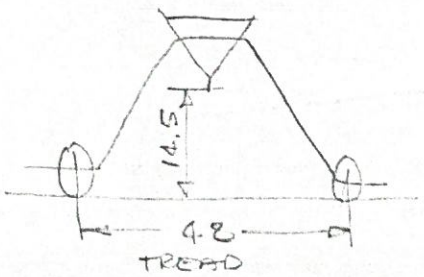
$(13)(41.71) - (20)(8.19) = (410)X \; ; \; X = 0.93$

$\%MAC = \frac{9.78}{30} = 32.6\%$ ←

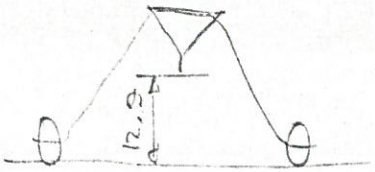
DROP TEST CONDUCTED AT GIBBS 12-30-49

CONFIG: W.E. + CHANNA, G.W. = 377#
ON GREASED PLATES.

W.E. LOAD ON GEAR:



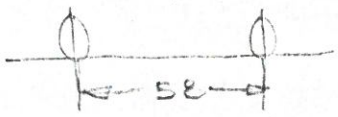
W.E. + CHANNA:
(377#)



WHEELS JUST OFF:

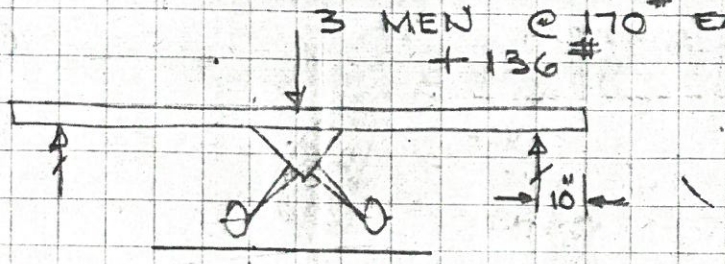
POSITION JUST BEFORE DROP	MAXIMUM TREAD @ DROP	ACCEL.	DROP HEIGHT C.G. MOVES FROM STATIC POS. 1 "g"
WHEEL 2" OFF	60.7	1.3	6.6
3"	62	1.5	7.6
4.5"	63.2	1.6	9.1

STATIC: W.E. + 2 PEOPLE (135# & 185#)
G.W. = 535# (1.42 g's)

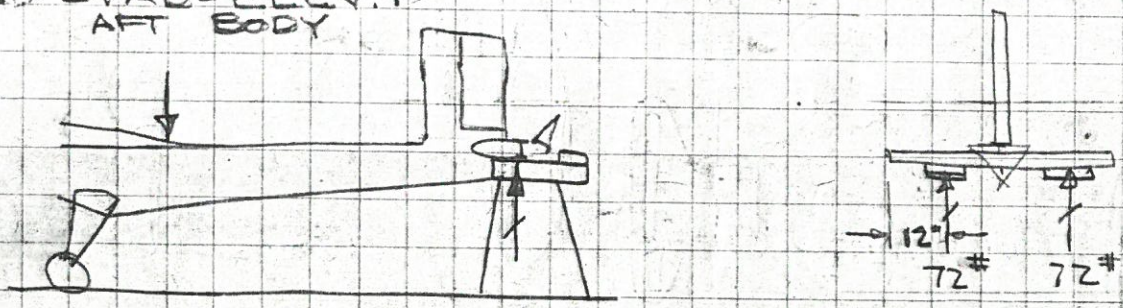


SUMMARY ~ STRUCTURAL TEST PROCEDURE & LOADS

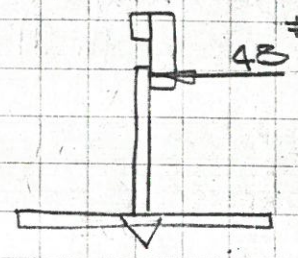
I WING:



II STAB-ELEV.: AFT BODY

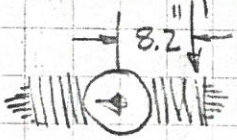


III FIN-RUDDER: AFT BODY

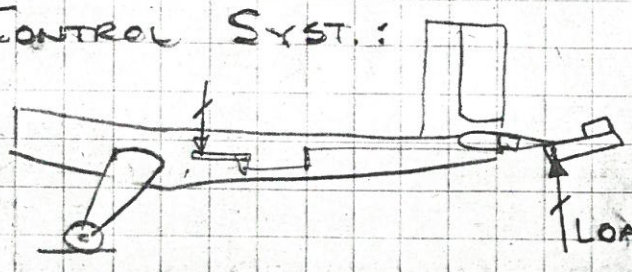


AIRPLANE RESTRAINED AT WING TIPS

IV ENGINE MOUNT: FWD. BODY



V CONTROL SYST.:



CONTROL	SCALE LOAD
ELEV.	24#
RUDDER	14#
AIL.	16# (EACH)
FLAP	23# (EACH)

VI LANDING GEAR

2 CONDITIONS:
(1) LEVEL ATTITUDE
(2) 3-POINT "

DROP ON COUNT OF 3.

INCREASE h TO POINT WHERE TIRE DEFLEC. IS EXCESSIVE & NOTE h.

PROBLEMS MET & SOLVED

1. ENGINE STARTING
2. GROUND LOOPING
3. WHEEL BEARING GALLING & SEIZING
4. THROTTLE CONTROL
5. ENGINE MOUNT RIVETS "POPPING"
6. IGNITION WIRE FAILURE
7. SHOCK ABSORPTION
8. STABILIZER SETTING
9. AIRSPEED SYSTEM
10. TACHOMETER OPERATION
11. LOW ENGINE POWER WITH O-45-1 ENGINE